KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
ELECTRICAL ENGINEERING DEPARTMENT

EE380 [091]	SEC#_____	Quiz # 9
Name: Key Solution	ID:_____	Grade:_____

Use Nyquist to find the stability for a unity feedback control system with open loop function given by

$$K\,G(s)H(s) = \frac{K}{s(s+2)(s+10)}$$

Select your Nyquist contour such that the pole at origin is inside it (P=1).

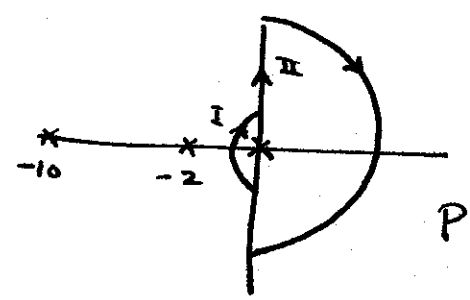
Ch Eqn: $s^3 + 12s^2 + 20s + K = 0$

Using R.H.

s^3	1	20	
s^2	12	K	$\Rightarrow$ $0 < K < 240$ (stable)
s^1	$\frac{240-K}{12}$		
s^0	K		

Along I : $s = \rho e^{j\theta}$, $\theta \in [180, 90]$

$KGH \simeq \frac{K}{s} = \frac{K}{\rho} \angle -\theta$



P = 0

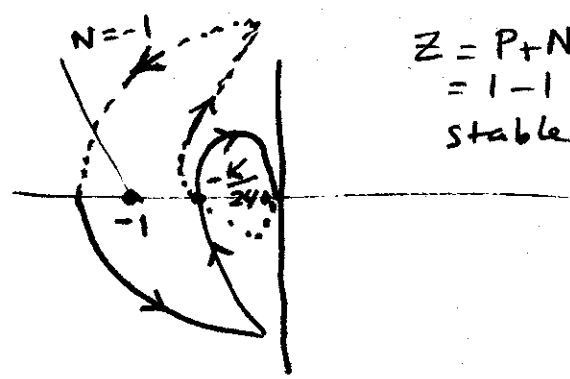
Along II : $s = j\omega$

$$|KGH| = \left|\frac{K}{j\omega(2+j\omega)(10+j\omega)}\right| = \frac{K}{\omega\sqrt{\omega^2+4}\sqrt{\omega^2+100}}$$

$$\angle KGH = -90 - \tan^{-1}(\omega/2) - \tan^{-1}(\omega/10)$$

$\angle = -180 \Rightarrow \omega^2 = 20 \Rightarrow \omega = \sqrt{20}$

$$|KGH|_{\omega=\sqrt{20}} = \frac{K}{\sqrt{28}\sqrt{24}\sqrt{120}} = \frac{K}{240}$$



$Z = P + N$
$= 1 - 1 = 0$
stable

$N=-1 \Rightarrow \frac{-K}{240} > -1 \Rightarrow \frac{K}{240} < 1 \Rightarrow K < 240$

$\therefore$ stable if $0 < K < 240$